DXP MultiSCA Firmware

The MultiSCA variants of the DXP firmware accumulate counts in up to 16 predefined single channel analyzer (SCA) regions. These regions are defined in terms of bins in the normal multichannel analyzer (MCA) spectrum, and can overlap arbitrarily. All MultiSCA firmware variants can run in standard MCA mode as an aid in setting up the SCA regions. Note that SCA counters are implemented in fast programmable logic so that the load on the digital signal processor (DSP) is minimized and throughput is not degraded relative to the standard variant.

Currently, there are four defined variants of the MultiSCA firmware; one runs in single-point mode, while the other three incorporate scanning or mapping operation, where SCA data are taken for many points with minimal dead time between scan points (and without reading out data between points). The mapping variants differ only in the storage of the SCA output data.

SCA Definition:

The number of SCAs is specified with the DSP parameter `NUMSCA`, which can range from 0 to 16. For SCA *n* (where *n* runs from 0 to 15), the bin limits are specified using the parameters `SCAnLO` and `SCAnHI`; all output counts that fall in the specified range of MCA bins (inclusive) are included in the SCA total.

Summary of DSP parameters used for SCA definition:

`NUMSCA` : Total number of SCAs defined (16 maximum)

`SCAnLO` : Lower bin limit of SCA n (0 ? n ? 15)

`SCAnHI` : Upper bin limit of SCA n (0 ? n ? 15)

Single Point SCA Acquisition:

The simplest variant of the MultiSCA firmware acquires SCA data for a single point only; storing multiple data points in memory is not supported. The SCA data are stored in internal DSP data memory; 32 bits are used for each SCA total. SCA data acquisition and MCA data acquisition can occur simultaneously. SCA data acquisition is enabled by setting the `SPECIALTASK` bit (bit 11) of the DSP parameter `RUNTASKS` (the bits of `RUNTASKS` are used to control various aspects of the processing). MCA acquisition is enabled by default, and can be disabled by setting the `SKIPSPECTRUM` bit (bit 12) of `RUNTASKS`. Disabling the MCA acquisition reduces the event processing time thereby freeing up some resources, which can make some difference when running at the highest count rates. Statistics for the single point MultiSCA run are stored in the same locations as for an MCA run, using the normal DSP parameters – `LIVETIME`*n* (3 16-bit words;

n = 2(msw), 0, 1(lsw)), REALTIMEn (3 words), FASTPEAKS*n* (2 words, *n*=0(msw), 1(lsw)) and EVTSINRUN*n* (2 words).

The output SCA data are stored in the SCADATA buffer, which contains 32 16-bit words in DSP data memory space. The DSP parameter SCADSTART points to the beginning of that data buffer in data memory; the parameter SCADLEN stores the length of the buffer. For each SCA, the lower 16-bit word is stored first in the buffer. The SCADATA buffer is arranged as follows:

Word 0:	SCA 0 data, bits 0-15
Word 1:	SCA 0 data, bits 16-31
Word 2:	SCA 1 data, bits 0-15
Word 3:	SCA 1 data, bits 16-31
|	|
Word 30:	SCA 15 data, bits 0-15
Word 31:	SCA 15 data, bits 16-31

Summary of DSP parameters used to control single point SCA mode:

RUNTASKS:

Bit 11: Set to enable SCA data acquisition

Bit 12: Set to disable MCA data acquisition

SCADATA: stores SCA output data

SCADSTART: pointer to start of SCADATA buffer

SCADLEN: length of SCADATA buffer (in 16-bit words)

The single point MultiSCA version of the firmware is identified by a value of 8 for the DSP parameter CODEVAR.

MultiSCA Mapping:

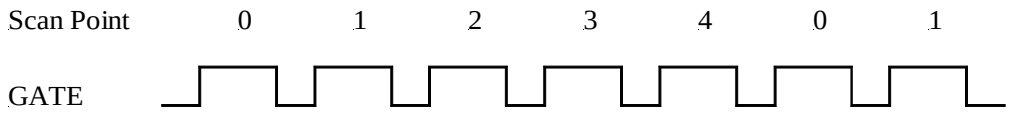
In mapping or scanning applications, the DXP records SCA data from many points, with minimal time needed to switch from one point to the next. Many scan points can be stored in onboard memory; the exact number depends on what memory is used (internal DSP memory or added external memory) and on the data format (word size for the SCA totals).

The scanning operation is the same for all variants. The GATE signal is used to signal the transition from one pixel to the next; the GATE interrupt must be enabled by setting bit 1 of the Timing Control Register (TCR); see the DXP User's manual. In general, the GATE signal should be asserted (TTL high) while taking data and deasserted between pixels. Note that if the IgnoreGATE bit is set in the Global Control Register (GCR), bringing the GATE signal low will not inhibit datataking (but will trigger the interrupt to switch points). The GATEINTPOL bit (bit 12) in the TCR selects which edge generates the GATE interrupt: GATEINTPOL=0 selects the falling edge, while GATEINTPOL=1 selects the rising edge.

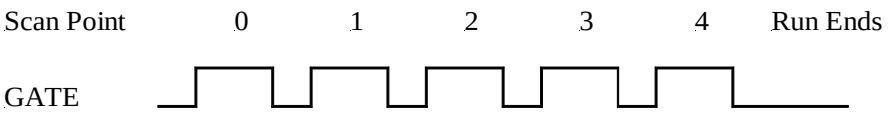
There are two basic modes for scanning. If MULTIMODE is set to 0, the user specifies a fixed number of points NUMPOINTS; after scanning through that number of points, the processor either jumps back to point 0 (if SINGLEPASS is set to 0) or stops taking data (if SINGLEPASS is set to 1). If MULTIMODE is set to 1, then the value of the SYNC input is used to define when to jump back to point zero: if SYNC is asserted during the transition, the first scan point is set active.

The different scanning scenarios are depicted pictorially below.

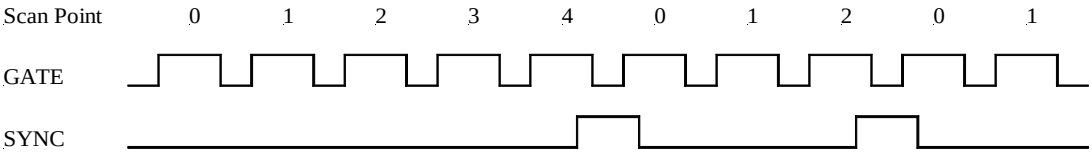
MULTIMODE=0, SINGLEPASS=0, NUMPOINTS=5



MULTIMODE=0, SINGLEPASS=1, NUMPOINTS=5



MULTIMODE=1



The maximum number of scan points is set by the amount of available memory. The scan point will not advance beyond the maximum value; if you attempt to scan past the

maximum number of data points, all the extra data will be combined with the data from the last scan point and the DSP parameter SCANERROR will incremented by 1.

Summary of DSP parameters used to control scanning:

MULTIMODE: Selects scanning mode.

0: Fixed number of points

1: SYNC signal identifies point 0

NUMPOINTS: For MULTIMODE=0, the user sets this parameter to specify the desired number of scan points. For MULTIMODE=1, this parameter indicates the actual number of scan points based on the GATE and SYNC inputs.

SINGLEPASS: For MULTIMODE=0, indicates whether to stop the run after scanning through NUMPOINTS. For MULTIMODE=1, this parameter is not used.

MAXPOINTS: Maximum number of scan points (calculated by the DSP based on the amount of available memory and NUMSCA).

SCANERROR: Indicates that the number of scan points exceeded the maximum.

0: No error

?1: MAXPOINTS exceeded; the value of SCANERROR indicates the number of extra points combined with the last valid scan point.

MultiSCA Mapping Variants:

There are currently three MultiSCA mapping variants; one uses internal DSP memory, while the other two use the optional external memory. The scanning operations are the same for each variant; the only difference is the location and format of the SCA output data.

MultiSCA Mapping, Internal Memory: In this variant, the SCA mapping data are stored in DSP program memory, in the same buffer used to store the spectrum for MCA data acquisition. The word size in DSP program memory is 24 bits; one word is used to store each SCA total as well as each statistics word. The granularity of the livetime and realtime measurements is either 400 ns or 800 ns per bit for 40 MHz (DXP-2X) and 20 MHz (Saturn) digitization respectively; the 24 bit word allows pixel times of up to only 6.7 or 13.4 seconds before rolling over. For each scan point, four statistics words are stored, so the record size for a single scan point is SCALEN = 4 + NUMSCA words. The length of the buffer is 12 kWords (12288 words), so the maximum number of scan points that can be stored is (12288/(4+NUMSCA)). For example, if NUMSCA=8, 1024 points can be stored. The SCA data is stored in the SPECTRUM buffer in program memory; the DSP parameter SPECTSTART points to the beginning of that buffer, while SPECTLEN is the length of the buffer.

The data record for a single scan point is organized as follows:

Word 0:	Livetime (400 or 800 ns units)
Word 1:	Realtime (400 or 800 ns units)
Word 2:	Input counts
Word 3:	Output counts
Word 4:	SCA 0 counts
Word 5:	SCA 1 counts
Etc.	

Length of single scan point: SCALEN = 4 + NUMSCA 24-bit words

Total length of scan record = NUMPOINTS * SCALEN words, starting at SPECTSTART in program memory.

The internal mapping version of the firmware is identified by a value of 9 for the DSP parameter CODEVAR.

MultiSCA Mapping, Compact External Memory (2 bytes/SCA): In this variant, the SCA mapping data are stored in optional external memory (up to 4 MB on the Saturn, 1 MB on the DXP-2X). The memory is organized in 16-bit words; 2 words are used for each statistics value, and 1 word is used for each defined SCA. The granularity of the livetime and realtime measurements is either 400 ns or 800 ns per bit, depending on the digitization rate; the 32 bits allocated for the time statistics allow pixel times of up to 1718 or 3436 seconds before rolling over. For each scan point, four statistics values are stored, so the record size for a single scan point is SCALEN = 4*2 + NUMSCA 16-bit words. For the DXP-2X, there is 1 MB of external memory (if installed), so the maximum number of scan points that can be stored is (524288/(8+NUMSCA)). For example, if NUMSCA=8, 32,768 points can be stored. For the Saturn, up to four times more external memory is available.

The data record for a single scan point is organized as follows (in terms of 16-bit words):

Words 0 - 1:	Livetime (400 or 800 ns units), always low word first
Words 2 - 3:	Realtime (400 or 800 ns units)
Words 4 - 5:	Input counts

Words 6 - 7:	Output counts
Word 8:	SCA 0 counts
Word 9:	SCA 1 counts
Etc.	

The external data must be read through the use of special runs in the DSP.

Length of single scan point: SCALEN = 8 + NUMSCA 16-bit words

Total length of scan record = NUMPOINTS * SCALEN words, starting at the base of external memory (external address = 0).

The compact external mapping version of the firmware is identified by a value of 10 for the DSP parameter CODEVAR.

MultiSCA Mapping, Standard External Memory (4 bytes/SCA):): In this variant, the SCA mapping data are stored in optional external memory (up to 4 MB on the Saturn, 1 MB on the DXP-2X). The memory is organized in 16-bit words; 2 words are used for each statistics value, and 2 words are used for each defined SCA. The granularity of the livetime and realtime measurements is either 400 ns or 800 ns per bit, depending on the digitization rate; the 32 bits allocated for the time statistics allow pixel times of up to 1718 or 3436 seconds before rolling over. For each scan point, four statistics values are stored, so the record size for a single scan point is SCALEN = 4*2 + 2*NUMSCA 16-bit words. For the DXP-2X, there is 1 MB of external memory (if installed), so the maximum number of scan points that can be stored is (524288/(8+2*NUMSCA)). For example, if NUMSCA=8, 21,845 points can be stored. For the Saturn, up to four times more external memory is available.

The data record for a single scan point is organized as follows (in terms of 16-bit words):

Words 0 - 1:	Livetime (400 or 800 ns units), always low word first
Words 2 - 3:	Realtime (400 or 800 ns units)
Words 4 - 5:	Input counts
Words 6 - 7:	Output counts
Words 8 - 9:	SCA 0 counts
Words 10 - 11:	SCA 1 counts
Etc.	

The external data must be read through the use of special runs in the DSP.

Length of single scan point: SCALEN = 8 + 2*NUMSCA 16-bit words

Total length of scan record = NUMPOINTS * SCALEN words, starting at the base of external memory (external address = 0).

The standard external mapping version of the firmware is identified by a value of 11 for the DSP parameter CODEVAR.